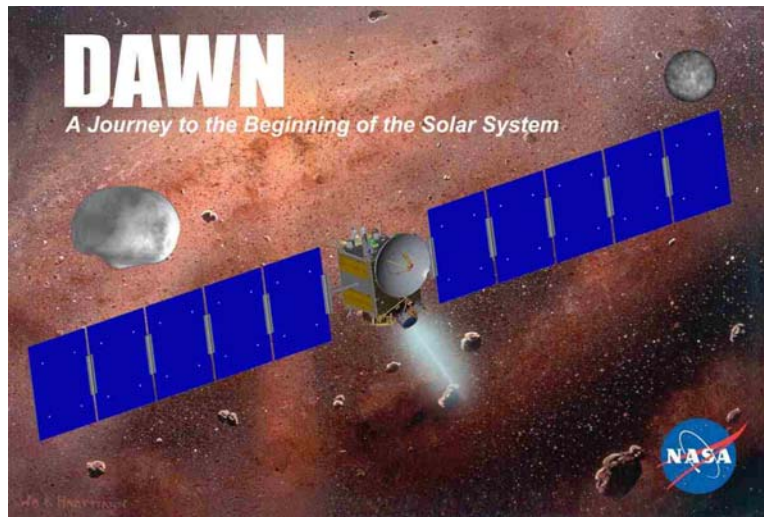


DAWN MISSION EDUCATION AND PUBLIC OUTREACH FIRST-YEAR EVALUATION REPORT



Submitted to:

Dawn E/PO Team

Submitted by:

Stephanie Baird Wilkerson, Ph.D.
Mid-continent Research for Education and Learning
Aurora, CO 80014

September 30, 2004



© 2004 McREL

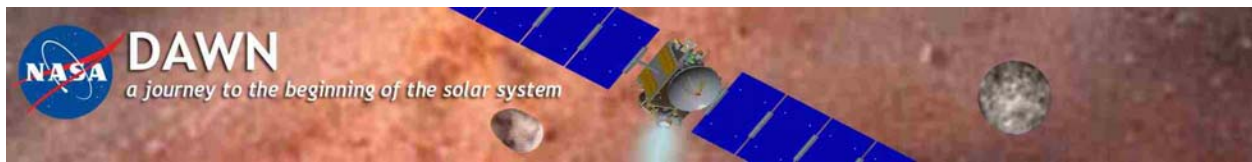
Cover credit: Background painting, "A cocoon nebula, perhaps the primordial solar nebula" by William K. Hartmann. Courtesy of UCLA.

ACKNOWLEDGEMENTS

This evaluation study represents a collaborative effort involving E/PO team members from McREL, New Roads School, and the University of Maryland. I gratefully acknowledge members of the E/PO team including John Ristvey, Joe Wise, Lucy McFadden, Jacinta Behne, Deb Aruca, and Judy Counley for their contributions to the evaluation process. Their integration of formative evaluation into project activities reflects their strong intent and determination to provide high quality outreach materials and resources on behalf of NASA's Dawn mission. I also would like to thank the many individuals whose contributions and assistance made this work possible, in particular, all of the workshop and pilot-test participants, including teachers, students, and administrators. These individuals graciously responded to the evaluator's information requests and shared meaningful thoughts and valuable insights throughout the data collection process. Finally, I would like to express great appreciation to those individuals who reviewed and provided feedback for this report.

TABLE OF CONTENTS

INTRODUCTION	1
The Dawn Mission Education and Public Outreach Initiative	1
EVALUATION DESIGN	2
Evaluation Questions	3
Data Collection	3
FINDINGS	4
Developing and Disseminating High Quality Products and Services	4
Reaching and Impacting Students.....	11
Reaching and Impacting Formal and Informal Educators	15
SUMMARY	19
RECOMMENDATIONS.....	20
APPENDIX A	21
Logic Model for Dawn Delivery and Communication Components.....	22
Logic Model for Dawn Education Development Component.....	23
Logic Model for Dawn Evaluation Component	24
APPENDIX B	25
E/PO Team Members' Response to Report Recommendations	26
 <u>LIST OF TABLES</u>	
Table 1: Sections of the Dawn Mission Web Site.....	8
Table 2: Paired Samples <i>t</i> -Tests for Pilot Sample Students	14
 <u>LIST OF FIGURES</u>	
Figure 1: Dawn E/PO product development and quality assurance process.....	6
Figure 2: The percentage of pilot-test teachers agreeing or strongly agreeing with quality and utility statements regarding the content module	7
Figure 3: Duration of visitor sessions on the Dawn Web site from entry to exit	9
Figure 4: The ten most frequently viewed pages on the Dawn Web site from 5/1/04 to 9/22/04...	10
Figure 5: The number of .pdf documents viewed from the Web site.....	10
Figure 6: Web users' method of accessing the Dawn Web site from 5/1/04 to 9/22/04.....	11
Figure 7: Mean ratings for students' level of agreement with statements regarding their perceptions of and experiences with science.....	13
Figure 8: Overall scores, pretest to posttest for all participating students	15
Figure 9: Sixth-grade scores, pretest to posttest.....	15
Figure 10: Eighth-grade scores, pretest to posttest.....	15
Figure 11: The percentage of teachers who agreed with statements regarding their use of the module	17
Figure 12: Participants' mean ratings related to the quality and utility of the CPR workshop.....	18



INTRODUCTION

As part of its Discovery Program, NASA awarded funding for the Dawn mission in December 2001. Dawn, the first mission to the Main Asteroid Belt, will investigate Ceres and Vesta, two of the largest protoplanets remaining intact since their formation. The mission will address the role of size and water in determining the evolution of the planets by measuring their mass, shape, volume, and spin rate with imagery and gravitational analysis of the spacecraft motion. Through this investigation, scientists aim to characterize the conditions and processes of the solar system's earliest epoch.¹ The Dawn mission offers a variety of information and data for the informal and formal educators as well as the public:

It [Dawn] brings images of varied landscapes on previously unseen worlds to the public including mountains, canyons, craters, lava flows, polar caps, and, possibly ancient lakebeds, streambeds, and gullies. Students can follow the mission over an entire K–12 experience as the mission is built, cruises to Vesta and Ceres, and returns data.²

Dawn begins its trek with a launch in 2006. The craft will travel four years before it reaches Vesta and another three years to reach Ceres with an end of mission date of 2015.

THE DAWN EDUCATION AND PUBLIC OUTREACH INITIATIVE

Dawn E/PO consists of a national team of Education and Public Outreach (E/PO) specialists from the University of Maryland, New Roads School (CA), and Mid-continent Research for Education and Learning that develop and disseminate high quality educational resources and materials in support of NASA's Dawn Mission. Dawn E/PO delivers emerging technology and scientific knowledge to the public, to classroom teachers and students, and to informal educators and participants. Through the Dawn E/PO Web site, students, educators, and the public engage in age-appropriate mission activities that include, for example, analyzing images for cratering, doing photometry on images to produce light curves, and discussing with mission scientists the importance of Vesta and Ceres to our understanding of solar system origins. Dawn E/PO concurrently uses innovative, educational tools to encourage student collaboration, visualization, and peer-review in ways that conform to and further define the national standards in math and science education.³

Target Audiences

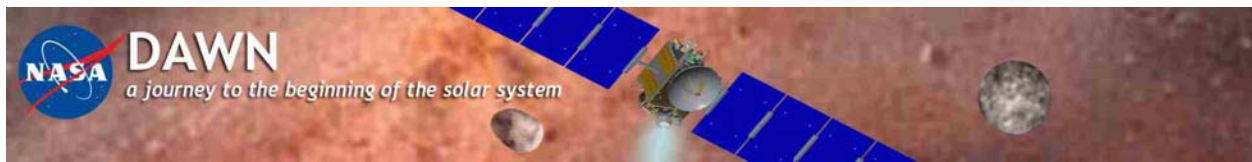
Dawn's target audiences include a.) educators (teachers and students, K–Post Secondary); b.) general public members (businesses, parents, politicians, adult learners, and retired); c.) media journalists⁴

¹ Dawn: A Journey to the Beginning of the Solar System (2002). The online site for the Dawn mission. Retrieved from the World Wide Web, June 5, 2003, <http://www-ssc.igpp.ucla.edu/dawn/>.

² Dawn Science Web site: <http://www-ssc.igpp.ucla.edu/dawn/>

³ Excerpt from the Dawn Mission E/PO final proposal, July 21, 2000.

⁴ Media requests are deferred to JPL media relations, however Dawn E/PO provides press packets and resources for media professionals via the Dawn mission Web site.



(national and local, broadcast, print, trade publications, Internet, instructional TV, radio and public service announcements); d.) informal educators (science museums/centers, arts community, speakers bureaus, youth programs, and service clubs); and e.) disadvantaged and underserved populations.

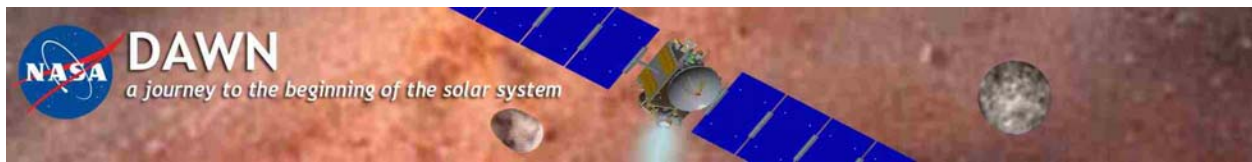
E/PO Approach and Outcomes

The Dawn E/PO team employs a strategic outreach approach, developed by Mid-continent Research for Education and Learning (McREL) and proven effective in the Genesis mission outreach, which supports NASA's vision and the Dawn E/PO goals. This approach is based on four components: Delivery, Communication, Education Development, and Evaluation. In conceptualizing its work based on the four components of the outreach model, the E/PO team identified eight, long-term ultimate outcomes, which are supported by 17 intermediate outcomes. Logic models were created to illustrate the activities, intermediate outcomes, data collection methods, and ultimate outcomes for each component (refer to Appendix A). The following lists the eight ultimate outcomes:

1. E/PO efforts reach broad target audiences through high quality products and dissemination mechanisms. Primary contacts share what they learn about the Dawn mission and associated science with their colleagues.
2. As a result of the knowledge and skills obtained from Dawn E/PO products and activities, participants have a better understanding of the formation of the solar system.
3. As a result of using Dawn E/PO products and activities, participants are interested in solar-system science.
4. Students will conduct science within a real-life context leading to increased academic achievement.
5. Educators have a better understanding of how to implement inquiry processes leading to improved practices.
6. Dawn E/PO products and services are of high quality and utility because they reflect audience needs.
7. Dawn E/PO can demonstrate the effectiveness of its outreach as evidenced by the impacts of its high quality products and activities.
8. Future mission E/PO efforts will have a blueprint from which to make informed decisions based on extensive documentation of lessons learned from Dawn E/PO.

EVALUATION DESIGN

The evaluation emphasizes a collaborative approach to evaluation, which requires the active participation of E/PO program staff in the design and implementation of the evaluation work. The evaluation design includes both qualitative and quantitative methodologies in order to provide formative and summative information. Formative evaluation information provides feedback to project staff, which is intended to guide project planning and development, and allows for a



continuous reflective process throughout project implementation. Summative evaluation information addresses the progress made toward intended outcomes of the outreach effort with a description of how the desired outcomes were realized. Furthermore, logic models are used as a tool for defining and depicting how project activities connect to project intermediate and ultimate outcomes.

EVALUATION QUESTIONS

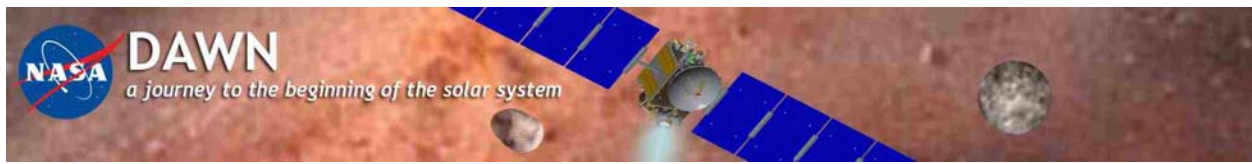
There are seven key evaluation questions, which link to E/PO intended project outcomes and are supported by additional evaluation questions, information sources, and data collection methods. The following key evaluation questions focus on impacts of the outreach initiative on the public, teachers, and students, as well as the quality and utility of materials and resources.

1. Do users of the Dawn E/PO products and services perceive them to be of high quality and utility?
2. To what extent do formal and informal educators and students access and use the Dawn E/PO materials and resources?
3. To what extent do public members access and use the Dawn E/PO materials?
4. Are participating students engaged and interested in the Dawn mission science as a result of using E/PO materials?
5. Do participating students have an increased understanding of the formation of the solar system?
6. To what extent has the Dawn E/PO effort enhanced participating teachers' capacity to teach space science?
7. To what extent has the Dawn E/PO effort affected public interest in and understanding of the Dawn mission?

DATA COLLECTION

The evaluation design encompasses both qualitative and quantitative data collection methods and, in some cases, more than one method is used to address a given evaluation question in order to strengthen the credibility of the findings. The field-test component of the evaluation includes a quasi-experimental design with pretest and posttest assessments of treatment and non-equivalent comparison groups. This design is employed in order to assess the impact of the Dawn E/PO curriculum materials on student learning. Data collection methods include pilot and field-test instrumentation for teachers and students, Web statistics, workshop participant feedback forms, Web-based surveys, and dissemination data.

Evaluation activities during this past year included the development of teacher and student data collection instruments for pilot and field testing of the first E/PO content module, *The History and Science of NASA's Dawn Mission*. Additionally, E/PO staff recruited teachers and schools for pilot and field testing. The findings presented in this report are based on the results of the spring 2004 pilot test, a review of outreach activities through project documentation and monthly reporting, and findings from E/PO professional development workshops.



FINDINGS

DEVELOPING AND DISSEMINATING HIGH QUALITY PRODUCTS AND SERVICES

The Dawn E/PO team develops and disseminates a variety of mission-related products and services to target audiences. E/PO products undergo a rigorous review process that includes expert review, pilot and field testing, and multiple revision periods. E/PO products include educational materials for a variety of target audiences and are disseminated primarily via the Web site, professional conferences, formal and informal educational settings, and public E/PO engagements. E/PO services include professional development workshops, conference presentations, Web site development, and information dissemination. This section presents development and dissemination information about the different E/PO products and services and describes how team members ensure their quality and utility. In addition, there is special emphasis on the quality and utility of the content modules based on feedback from pilot- and field-test participants.

Ultimate Outcomes

1. E/PO efforts reach broad target audiences through high quality products and dissemination mechanisms.
6. E/PO products and services are of high quality and utility because they reflect audience needs.

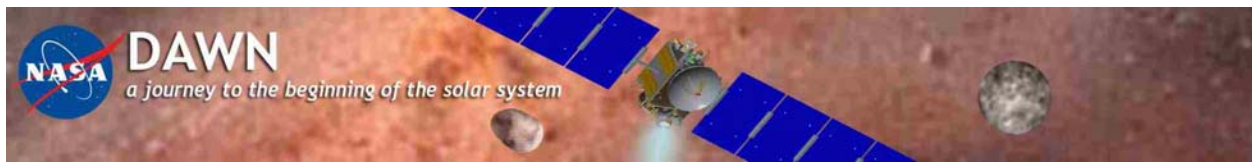
Key Evaluation Questions

1. Do users of the E/PO products and services perceive them to be of high quality and utility?
2. To what extent do informal and formal educators and students access and use the E/PO products and services?
3. To what extent do public members access and use the E/PO products and services?

Product Development

During the project period, the E/PO team engaged in developing the Dawn Web site, business cards, Dawn E/PO planning guide, the Dawn pull ups, and the e-newsletter (288 subscribers). The team also developed the *History and Science of NASA's Dawn Mission* content module, the *Find a Meteorite* stand-alone activity for formal and informal education settings, and a draft of the ion propulsion content module.

The *History and Science of NASA's Dawn Mission* content module is intended to engage middle school learners in the wonder and curiosity that is inherent in discovery. Participants explore the historical sequence of events that led to the Dawn mission. The module provides a real-life example that allows students to experience science and science thinking over time, from the discovery of asteroids and the asteroid belt to the new science and discovery that is part of the Dawn mission. The module includes teacher guides and student activities as well as vignettes that provide historical snapshots of the discovery of asteroids, the technology used or developed, and the social and political issues at the time. The content module consists of inquiry-based learning materials that guide students through a five-phase learning cycle. The module is aligned with the *National Science Education Standards* and the American Association for the Advancement of Science benchmarks for science education. During the project period, this product underwent peer review, pilot testing, and intensive revisions. Team



members also developed draft versions of independent learner guides and “non-formal” leader guides.

The *Find a Meteorite* activity introduces the importance of meteorites to the understanding of the origin of the solar system. Since scientists believe that some meteorites are pieces of the asteroid Vesta, they may be very old remnants of the solar system in its earliest stages. The activity provides information and insight that allows participants to share scientists’ expectations, based on meteoritic samples, of what we will find when the NASA’s Dawn Mission visits Vesta and Ceres. Comparison between actual data and the meteorites here on earth may confirm that we are in possession of very valuable material indeed. The hands-on activity is an introduction to meteorite identification that aims to help learners differentiate between meteorites, and terrestrial rocks. This activity has been presented with great success at the University of New Mexico Institute of Meteoritics, and a simplified version has been used many times with the general public during Astronomy Day in Albuquerque. During the project period, the first draft of this product for formal and informal education settings was developed. In the upcoming year it will undergo pilot and field testing.

The second E/PO content module currently under development focuses on ion propulsion and challenges high school students to consider the guiding question: “How do we get to the asteroid belt?” The activities may provide students with the opportunity to learn about both conventional propulsion systems as well as the ion propulsion system utilized by the Dawn mission. By comparing the different systems, students recognize the limitations of conventional propulsion systems and realize why there has not been another mission to the asteroid belt prior to Dawn. As the module unfolds, students develop their background knowledge of Newton’s Laws and Coulomb’s Law through readings, hands-on activities, discussions, an interactive simulation, manipulation of data, or exploration of resources. Equipped with an understanding of these physical science concepts, students then experiment with a computer-based ion propulsion simulation developed at the Jet Propulsion Laboratory as part of the Next Generation Ion Engine program. In subsequent sections, students synthesize their knowledge and, ultimately, demonstrate their learning relative to the standards addressed in the module. During the project period, components of this module were drafted and submitted to peer review. Next year, teachers will pilot and field test this module in their classrooms.

Rigorous Quality Assurance Review

The Dawn E/PO team has designed and implemented a product development and quality assurance process that includes initial peer and expert reviews, pilot and field testing in multiple sites, and iterative revising (see Figure 1). This development process ensures that the Dawn E/PO products are appropriate for the intended educational settings; meet the needs of students and educators; impact the knowledge, skills, and interests of participants; and are of high quality and utility to users. Each E/PO formal and informal education product will go through this process before it is broadly disseminated.

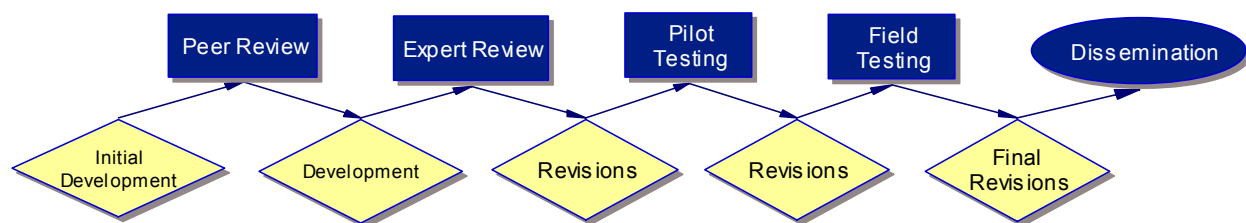
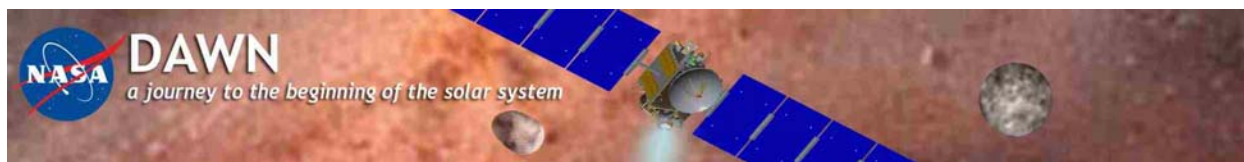


Figure 1. Dawn E/PO product development and quality assurance process.

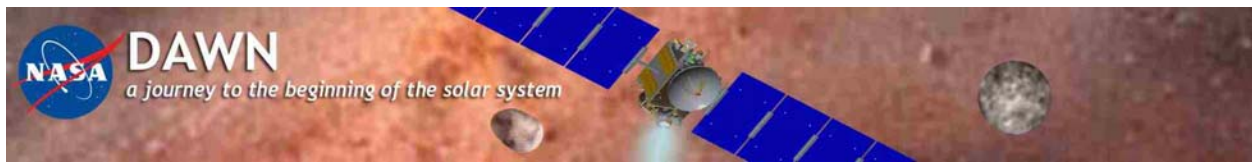
The purpose of the peer review sessions is to present product components to educators in order to collect initial feedback regarding its quality and utility such as, grade-level appropriateness, potential to create student interest, necessary student experiences and background information, anticipated instructional time, and potential in developing student inquiry skills and understanding of the science concepts. The purpose of pilot testing products is to gain preliminary feedback from a small number of users regarding the appropriateness, fit, quality, and utility of the product. This allows for the identification of issues, challenges, and characteristics regarding the product's design, content, pedagogy, implementation, and efficacy with students. The purpose of the field test is to study the revised materials in a larger number of settings and to examine the effectiveness of the product in achieving teacher and student goals. The field test also generates important formative feedback, similar to the pilot test, to guide further revisions and modifications.

During this project period, the E/PO team facilitated four peer reviews, also referred to as Core Planning Teams, with educators attending the Colorado Science Teachers conference, the Utah Science Teachers conference, and the Kansas Association of Teachers of Science conference. Two of the peer review sessions focused on components of the *History and Science of NASA's Dawn Mission*, one focused on the *Find a Meteorite* activity, and one focused on the ion propulsion content module. In total, E/PO team members received peer review feedback from 51 participants on these products. Additionally, five teachers in two schools pilot tested the *History and Science of NASA's Dawn Mission* in their classrooms. Those results are presented in the following sections.

User Perceptions of Product Quality and Utility

Three of the five pilot-test teachers in two schools provided in-depth feedback via the *Dawn Module Evaluation* survey regarding the quality and utility of the *History and Science of NASA's Dawn Mission* content module in their sixth- and eighth-grade classrooms. On a scale of 1 to 7, 1 being "not difficult" and 7 being "very difficult," teachers indicated that it was somewhat difficult to adapt the module to their teaching settings ($\chi=3.67$). Some teachers indicated that the layout and procedures of the module could be better organized and more clearly presented. Teachers were asked to indicate the extent to which they agreed or disagreed with several statements regarding the quality and utility of the content module (1=strongly disagree; 2=disagree; 3=neither agree nor disagree; 4=agree; and 5=strongly agree). Figure 2 presents the percentage of respondents who agreed or strongly agreed with statements related to the content and design of the module, its appropriateness for diverse students, and standards and assessment.

Teachers' perceptions of the quality and utility of the module provided rich, meaningful feedback to



guide module revisions—as intended during the pilot-test process. As shown in Figure 2, teachers indicated that improvements could be made to enhance the assessment and standards component of the module as well as its appropriateness for minority students. In general, most teachers thought that the content was scientifically accurate, that it promoted inquiry-based, hands-on learning, and that it was developmentally appropriate for the eighth grade. Through the pilot test, E/PO product developers learned that the content module was not appropriate for students in the sixth grade. Overall, most teachers agreed that the module was of high quality and utility.

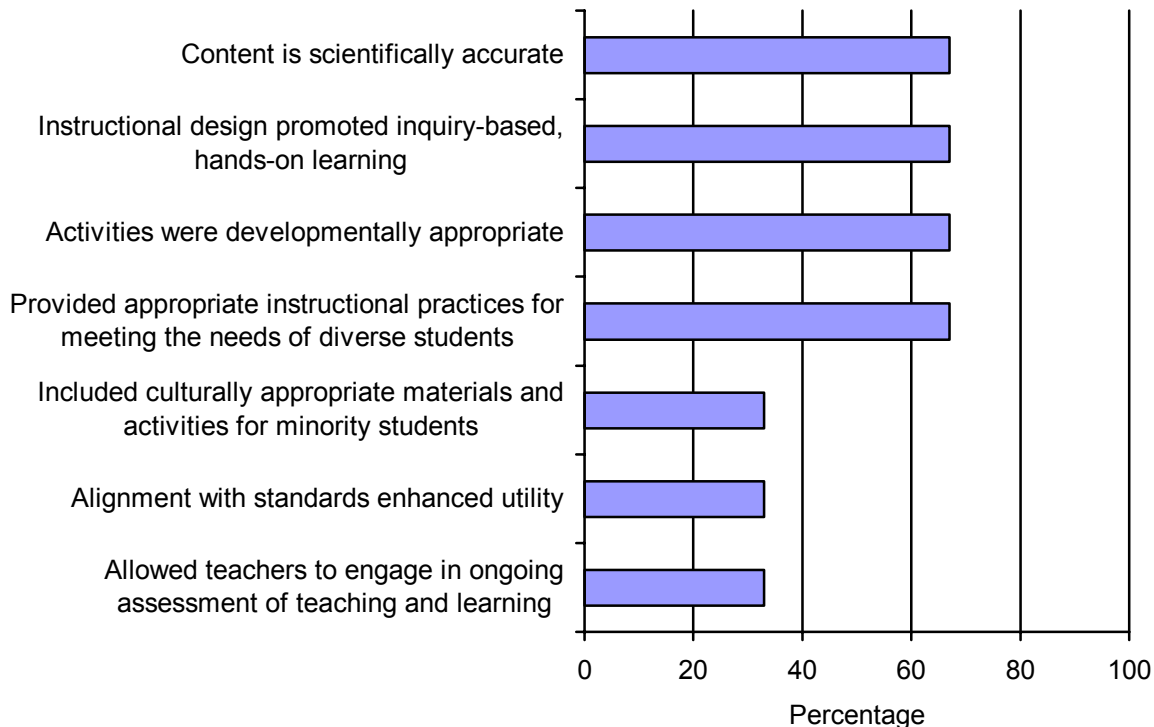


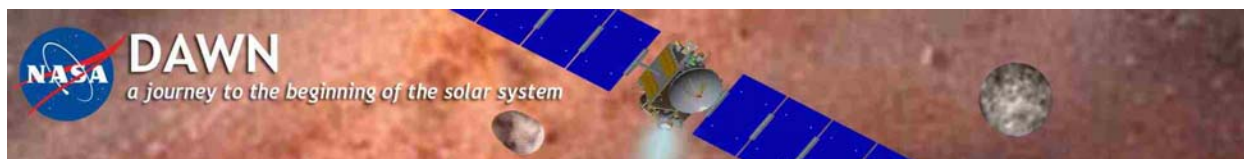
Figure 2. The percentage of pilot-test teachers (n=3) agreeing or strongly agreeing with quality and utility statements regarding the content module.

Outreach Dissemination and Visibility

E/PO team members provide access to materials, resources, and information regarding the Dawn mission through various means. During this first year of development, outreach efforts focused on promoting visibility through presentations or displays at educational and public events as well as the new Web site. As development efforts progress in the upcoming years, the dissemination of print materials, such as business cards, bookmarks, fact sheets, and posters, will serve as mechanisms for increasing mission visibility.

Conferences, Presentations, and Workshops.

During the project period, E/PO team members represented the Dawn mission at several educator and



public events. The education events included the National Science Teachers Association annual conference, the Utah Science Teachers conference, the Colorado Science Teachers conference, the Kansas Association of Teachers of Science conference, and the Space Education in Area Schools conference, Houston, TX. The public events included the Denver Museum Educator Night, the Jet Propulsion Laboratory open house, and the Lunar and Planetary Science conference, where the Dawn mission pull up was visible. Presentations were made on behalf of the Dawn mission at the Utah State Teachers conference (25 teacher attendees), the National Science Teachers Association (10 teacher attendees) Lunar Planetary Science conference (60 attendees), the COSPAR international conference (30 attendees), the Milken Community High School (student attendees), and the Western Alliance Conference of the International Planetarium Society (150 attendees). Members of the E/PO team also facilitated a workshop on Calibrated Peer Review involving five teacher participants, which will be discussed further in subsequent sections.

Dawn Mission Web Site.

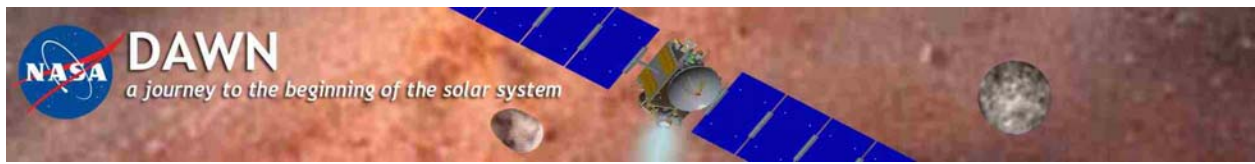
The development of the Dawn Mission Web site was a central focus of E/PO efforts during this project period. The site is a comprehensive information source and dissemination mechanism for the Dawn mission. It includes seven main sections that pertain to various aspects of the mission. Table 1 lists the Web site sections and subsections that team members developed this project period. In addition to these sections, team members developed and posted the Dawn Dictionary and the *Find a Meteorite* Web activity.

Table 1.
Sections of the Dawn Mission Web Site

Web Site Section	Brief Description
Main Sections	
Mission	Information on the mission background, timeline, schedule, trajectory, status, spacecraft, etc.
Science	Overview of the science involved in the mission
Technology	Information on the technology involved in the mission
Education	Currently lists participating education and outreach partners
People	Lists mission management and science team; team member interviews
Multimedia	Provides a comprehensive image gallery for the mission
Get Involved	Presents opportunities for people to participate in outreach activities
Target Audience Sub-Sections	
Dawn Kids	Games and activities for kids; ion propulsion game currently posted
Dawn Classrooms	Learning resources for parents and educators; professional development opportunities
Dawn Community	Activities and information for community members including ways to get involved
Dawn Media	Press information and packets with the latest news and resources for media professionals

From the time the site went live in May 2004 to the time this report was written (9/22/04), the site received 137,699 hits, 15,223 page views, and 923 visitor sessions.⁵ Almost all visitors (99%) accessing the Web site were from the United States, although there was also a very small amount of activity from China, Portugal, Great Britain, Canada, and the Netherlands. Thirty-two percent of

⁵ A visitor session is a session of activity (all hits) for one visitor of a web site.



visitor sessions lasted over one hour, 13 percent lasted 30 minutes to one hour, 27 percent lasted 30 seconds to 30 minutes, and 28 percent lasted less than 30 seconds (see Figure 3).

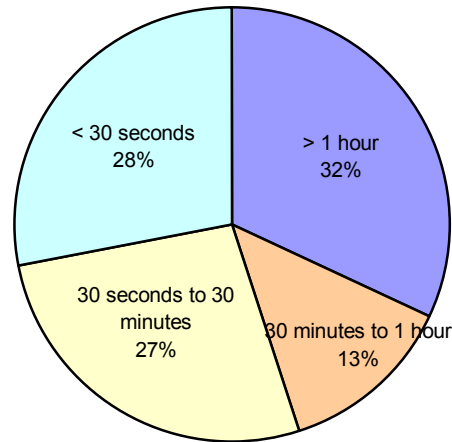


Figure 3. Duration of visitor sessions on the Dawn Web site from entry to exit.

Figure 4 shows the top ten page views for the Dawn Web site since May 2004. The Dawn Homepage had the greatest number of page views (3,181). Of the section entry pages, the Mission entry page was the most popular with 3,438 page views including those for the spacecraft, trajectory, schedule, timeline, and background subsections. The Find a Meteorite main page and the Explore a Meteorite subject page received a total of 1,195 page views during project period.

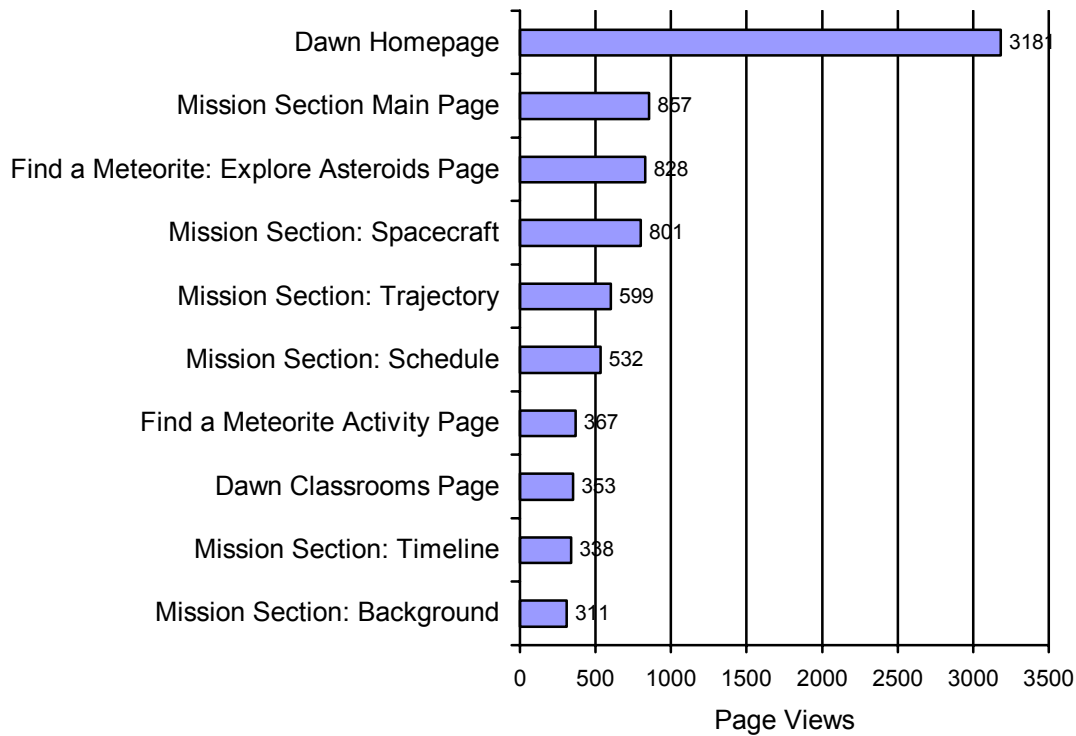
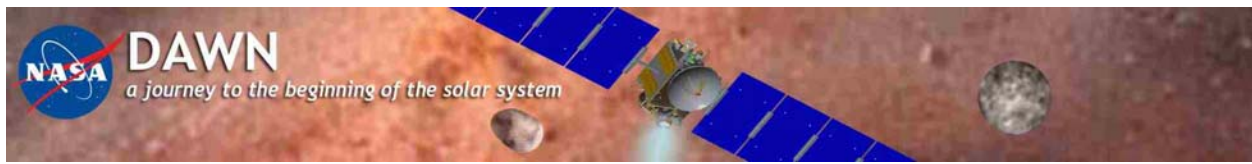


Figure 4. The ten most frequently viewed pages on the Dawn Web site from 5/1/04 to 9/22/04.

Of the .pdf documents available for download on the Dawn Web site, the field test study description was most frequently viewed by visitors (114 page views), followed by the media press package (17 page views), and description (13 page views) and sign-up sheets (13 page views) for the Calibrated Peer Review professional development workshop (see Figure 5).

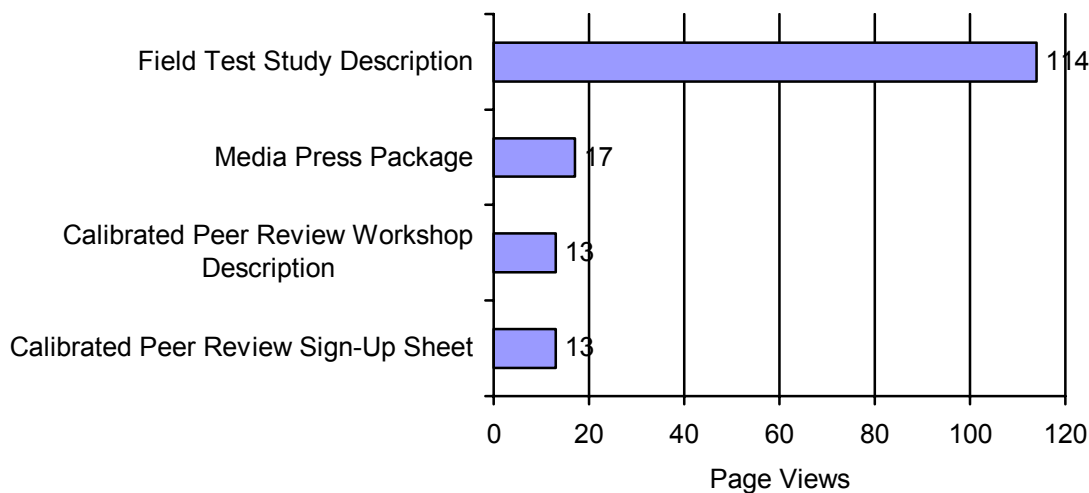
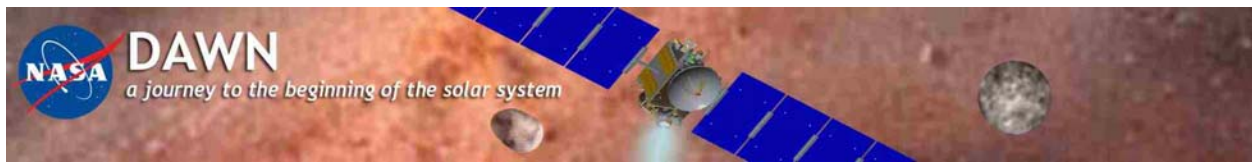


Figure 5. The number of .pdf documents viewed from the Web site.



Target audiences can learn about the Dawn Web site through the Dawn newsletters; all project materials, which include the Web address; search engines; and links from other space science Web sites. Most frequently, links from external pages accounted for 10,394 page views on the Web site, followed by 4,150 page views resulting from direct address or bookmarks, and 447 page views made by visitors linking from an Internet search engine (see Figure 6).

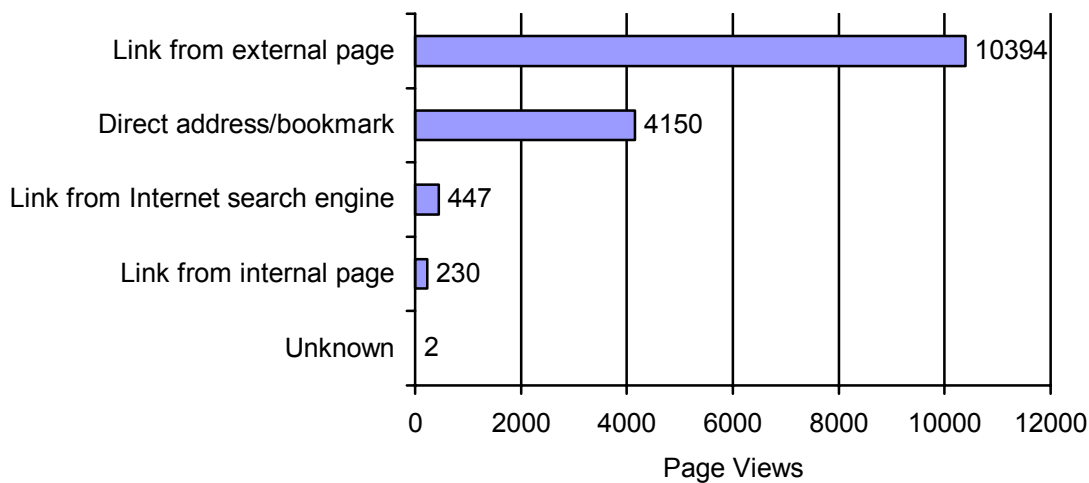


Figure 6. Web users' method of accessing the Dawn Web site from 5/1/04 to 9/22/04.

REACHING AND IMPACTING STUDENTS

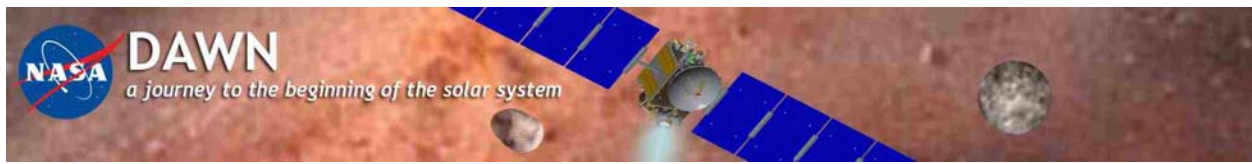
The E/PO team aims to improve student interest and learning in space science by engaging students in high quality, standards-based activities. E/PO team members reach their student audience through teachers, who use the Dawn science materials in their classrooms; informal educators, who facilitate student activities in museum, after-school, and summer school settings; and independent learners who access the activities on the Dawn mission Web site.

Ultimate Outcomes

2. As a result of the knowledge and skills obtained from Dawn E/PO products and activities, participants have a better understanding of the formation of the solar system.
3. As a result of using Dawn E/PO products and activities, participants are interested in solar-system science.
4. Students will conduct science within a real-life context leading to increased academic achievement.

Key Evaluation Questions

4. Are participating students engaged and interested in the Dawn mission science as a result of using E/PO materials?
5. Do participating students have an increased understanding of the formation of the solar system?



The Dawn science materials promote hands-on, inquiry-based learning with activities that allow students to connect classroom lessons to “real life” experiences. Enhancing student awareness of space-science careers is one component of making these “real life” connections. The learning cycle⁶ for each module supports student-initiated learning and facilitates process-oriented, critical thinking skills.

Characteristics of Participating Students

Five teachers in two suburban schools participated in the pilot test of the *History and Science of NASA's Dawn Mission* content module. These teachers implemented all or components of the module with over 100 students in the sixth, seventh, and eighth grades. Fifty-three percent of the participating students were male and 47 percent were female. On average, students participated in the module's learning activities over a period of 14 days, 70 minutes a day. Before and after implementing the materials, sixth- and eighth-grade teachers administered the knowledge and skills assessment as well as the interest survey to the students.⁷

Increasing Student Interest in Solar-System Science

E/PO team members highly value students' experiences and perceptions of participating in the module's activities. As such, students were asked to provide anonymous feedback about the module activities pertaining to what interested them and what needed improvement as well as overall feelings toward science, inquiry, space science careers, and making connections between science and real life.

Students were asked to report the most interesting thing that they learned from the *History and Science of NASA's Dawn Mission* content module, and they most frequently commented that learning about asteroids and albedo was most interesting to them. The following are examples of students' comments:

“The most interesting thing that I learned is about all of the people that discovered asteroids.”

“I knew what asteroids were but I had no idea about how they were discovered...”

“Learning about the albedo of an asteroid and learning about the ‘missing planets’.”

“The most interesting thing I learned about the Dawn Mission is one how the technology has expanded since 1760 to modern day. I also liked doing the albedo experiment, but it would be fun to do a bigger variety of experiments.”

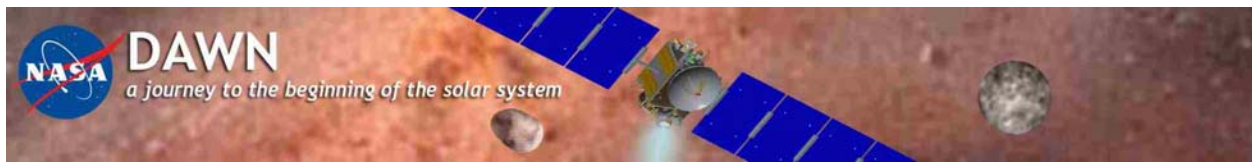


Students develop a timeline as part of the Dawn content module activities.

Students also were asked what would make the module more fun and interesting. Resoundingly, students wanted to do more experiments associated with the content of the module. Students also offered important formative feedback by commenting that some of the vignettes were confusing

⁶ The learning cycle for each module is divided into the following five components: Briefing, exploration, development, interaction/synthesis, and assessment.

⁷ Seventh-grade teachers were only piloting components of the module with a small number of students in one school, therefore, student data were not collected from this group.



and that they felt a bit overwhelmed by the number of questions and writing in the module. The following quotes are examples of the student responses regarding what would make the module more fun and interesting:

“More science experiments and fun activities to go with the vignettes.”

“Less writing and more experiments.”

“More experiments would be fun so that we could know and feel how asteroids were discovered. Then we would know how hard it was. A little more instructions and clearer instructions would make the activities easier to understand.”

“If we actually had a piece of an asteroid.”

As stated previously, the student interest survey was administered before and after pilot-test teachers implemented the materials. In addition to the open-ended items just mentioned, students responded to a series of Likert-scale items (4=Really agree, 3=Agree, 2=Disagree, 1=Really Disagree) related to students’ understanding of science’s connection to real life, their interest in science, their knowledge of conducting science investigation, and their interest in space-related careers. Figure 7 presents the mean ratings of students’ responses before and after participating in the module activities.

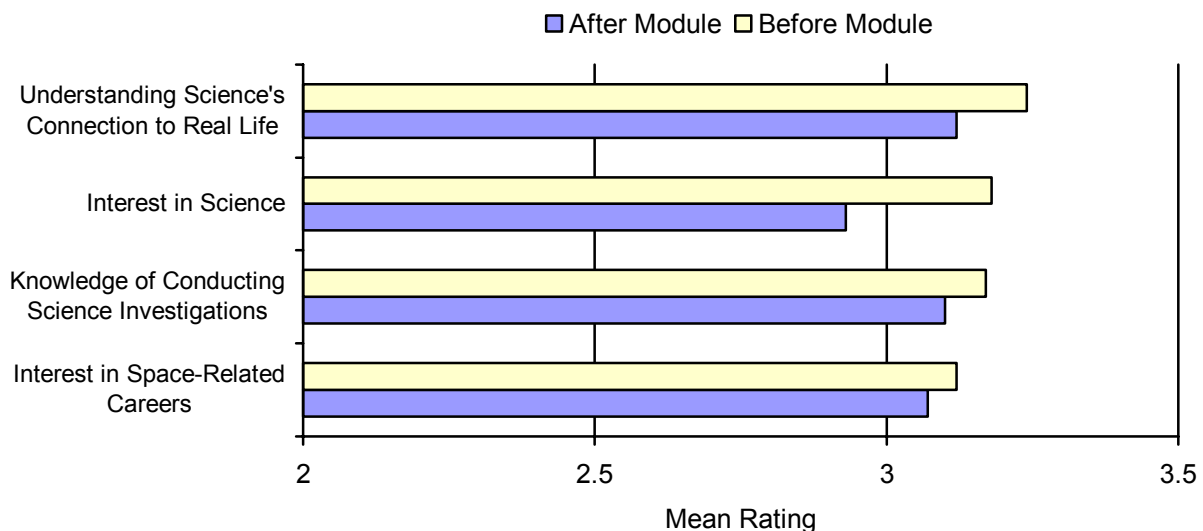
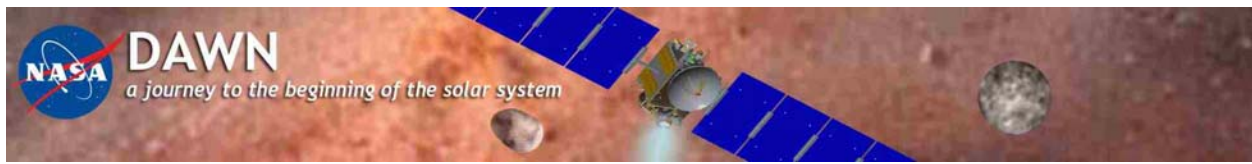


Figure 7. Mean ratings for students’ level of agreement with statements regarding their perceptions of and experiences with science.

The results indicate that students, on average, had a high-level of agreement with the survey statements before they participated in the module’s activities. Students’ ratings decreased slightly after using the module, but not to a significant extent. Given that this was administered during the pilot study and that teacher implementation was unguided and varied widely, it is difficult to make interpretations of the slight decrease in student interest and perceptions. It is important to note that at this stage in product development these results are used formatively to make modifications to the materials.

Increasing Student Knowledge and Skills



Sixty-three students (56 sixth graders and 7 eighth graders) completed the pre and post knowledge and skills assessment developed by the Dawn E/PO team. The assessment consisted of eight, multiple-choice items; three, “True or False” items; and seven, short answer items. The highest possible score on the assessment was 20 points. The results indicate that students showed significant improvement over the study period. Table 2 presents the results of the paired-samples *t*-tests⁸ for all students, sixth-grade students only, and eighth-grade students only. It includes the pretest and posttest scores, standard deviations, gain scores, *t*-test results, and effect sizes.⁹

Table 2.
Paired Samples *t*-Tests for Pilot Sample Students

	Sample (n)	Pretest Score (of 20)	Posttest Score (of 20)	Pre-Post Mean Difference	<i>t</i> value	Degrees of freedom (<i>df</i>)	<i>p</i> value ^b	Effect Size (Cohen's <i>d</i>)
All Students	63	11.87 (2.83) ^a	13.62 (2.8)	1.75	5.67	62	.000	.62
Sixth Grade	56	11.64 (2.84)	13.48 (2.84)	1.84	5.66	55	.000	.65
Eighth Grade	7	13.71 (1.89)	14.71 (2.36)	1.00	1.03	6	.345	.47

^a Standard deviations are shown in parentheses.

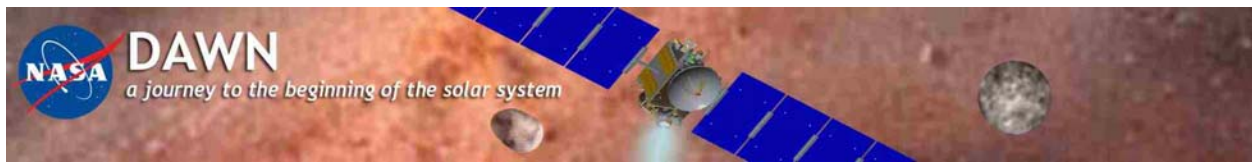
^b Alpha=.05; therefore *p* values less than or equal to .05 are significant.

The average student score on the assessment activity before using the Dawn E/PO materials was 11.87. After the module, the average student's score was 13.62. The difference between this average pre- and post-score was highly statistically significant ($p < .000$; see Figure 8). Given that sixth-grade students comprised the majority of the pilot sample, their results were highly significant and very similar to those for the overall group (see Figure 9). Although the eighth-grade students showed learning gains, they were not significant (see Figure 10). However, given the very small sample of only 7 students, caution is warranted in interpreting these results.

Moreover, calculations indicate large effect sizes of +.62 and +.65 for the entire group and for sixth-

⁸ In this case, a paired-samples *t*-test is used as a test of statistical significance of the differences between a group's pretest scores and posttest scores.

⁹ An effect size is a unit of measurement that expresses “practical significance,” or the magnitude of the increase or decrease in achievement of students. Effect sizes are expressed in standard deviation units. For example, an effect size of 1.0 indicates that student scores increased 1.0 standard deviation from their pretest score to their posttest score. Effect sizes were estimated using Cohen's *d* formula in which the mean pretest score is subtracted from the mean posttest score and then divided by the pooled standard deviation for the pretest and posttest.



grade students, respectively; and a medium effect size of $+0.47$ for eighth-grade students. Effect sizes can be translated into percentile points for ease of interpretation. In this case, the effect sizes reflect what would be an average learning gain of 23 percentile points on a standardized test across all grades, a 24-point gain for sixth-grade students, and 18-point gain for eighth-grade students. Based on this information, it may be interpreted that students' use of the materials resulted in an increase in their understanding of the science concepts and standards embedded in the materials.

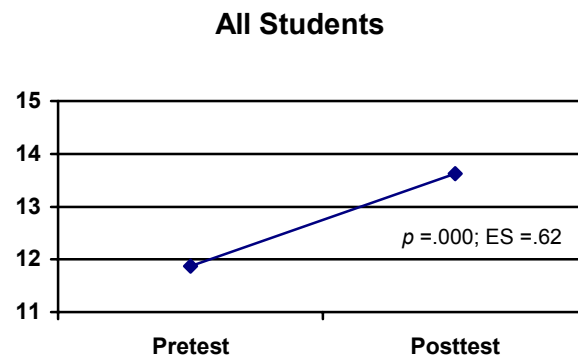


Figure 8. Overall scores, pretest to posttest for all participating students.

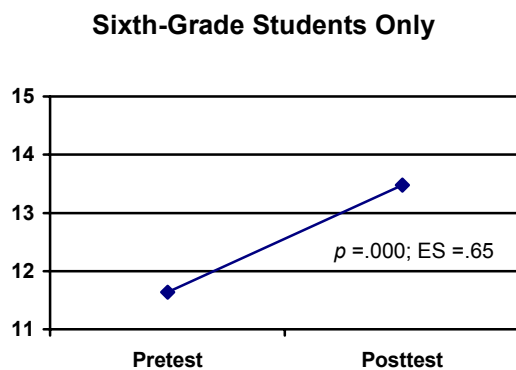


Figure 9. Sixth-grade scores, pretest to posttest.

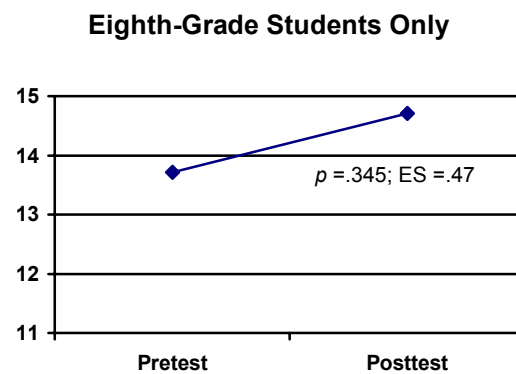
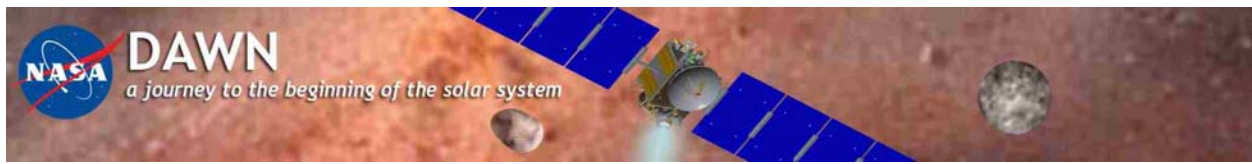


Figure 10. Eighth-grade scores, pretest to posttest.

REACHING AND IMPACTING FORMAL AND INFORMAL EDUCATORS

E/PO team members aim to improve formal and informal educators' access to standards-based materials as well as to deepen their understanding of how to facilitate inquiry-based practices. Through the Dawn outreach efforts, educators will be able to access standards-based curriculum modules, information on the science and the mission, and professional development. Team members reach their educator audience primarily through the Web site, professional conferences,



workshops, and the education development networks. During this past year, evaluation focused on collecting feedback data from teachers in pilot-test sites and participants in professional development workshops.

Ultimate Outcome

5. Educators have a better understanding of how to implement inquiry process leading to improved practices.

Key Evaluation Question

6. To what extent has the E/PO effort enhanced participating educators' capacity to teach space science?

Accessing Dawn Materials and Resources

Educators seeking standards- and inquiry-based space science materials and resources will be able to access and participate in the Dawn E/PO outreach efforts in several ways. Educators can become a NASA Field Associate by engaging in a long-term relationship with Dawn E/PO that involves pilot- and field-testing curriculum materials; completing the *Teacher Informational Questionnaire* and the *Dawn Module Evaluation*; and disseminating E/PO materials and resources. As E/PO products become available, educators will be able to access the materials without becoming a field associate. In the upcoming year, these non-network educators will be able to download the educational materials from the Dawn Web site and provide feedback voluntarily by completing an on-line survey. Educators also access and participate in the E/PO initiative by attending Dawn workshops and trainings, where they can learn about the variety of Dawn resources and materials and provide feedback by completing the *Participant Evaluation* form. Additionally, educators can access educational materials and resources through the Dawn Web site and will be able to provide feedback voluntarily on the content and utility of the Web site by completing the online *Dawn Web Site Evaluation* form.

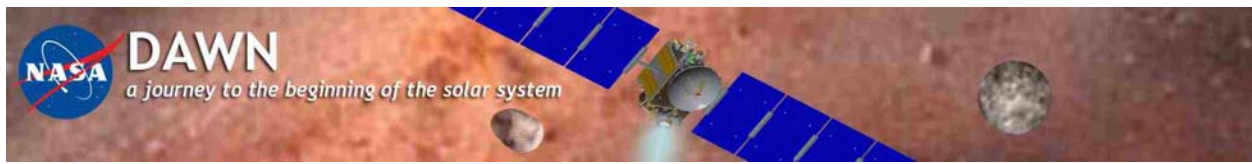
Characteristics of Educator Participants

Given that this past project year focused on materials development, evaluation efforts targeted formal education audiences only for initial pilot-test feedback. Next year, new materials will be pilot- and field-tested with informal education audiences, such as museums and after-school programs.

Of the five teachers who pilot-tested the *History and Science of NASA's Dawn Mission*, three provided feedback via the *Teacher Informational Questionnaire* and the *Dawn Module Evaluation*. Two of these teachers taught sixth grade and one teacher taught eighth grade during the 2004–2005 school year. Both participating schools were suburban and almost 20 percent of the students were categorized by their teachers as economically



Teachers at the Utah Science Teachers Conference search for Vesta.



or academically disadvantaged.¹⁰

Capacity Building in Study Sites

Teachers were asked to respond to several items related to their capacity before and after implementing the *History and Science of NASA's Dawn Mission* content module. Given that these findings only represent the experiences of 3 teachers, it is important to remember that data from the pilot test is not intended as a summative measure of product efficacy, but rather as a means of obtaining critical, constructive feedback for improvement.

Before and after using the content module, teachers described themselves as being comfortable in using inquiry-based, hands-on activities in the classroom and as somewhat knowledgeable about space-related topics and issues. Aside from the Dawn mission, teachers indicated that they were not very familiar with other space-related or NASA education programs that are available to teachers. Teachers' use of the Dawn materials did not result in any drastic changes in how they perceived themselves related to these characteristics.

Teachers were asked to respond to four statements regarding their perceptions toward science and their use of the module. Of the three teachers responding to these items, only 33 percent (or, one teacher) agreed that using the module increased their interest in science; resulted in a better understanding of how to facilitate inquiry-based, hands-on learning processes; improved understanding of how to tie science learning to real-life contexts; and resulted in them liking to teach science more (see Figure 11).

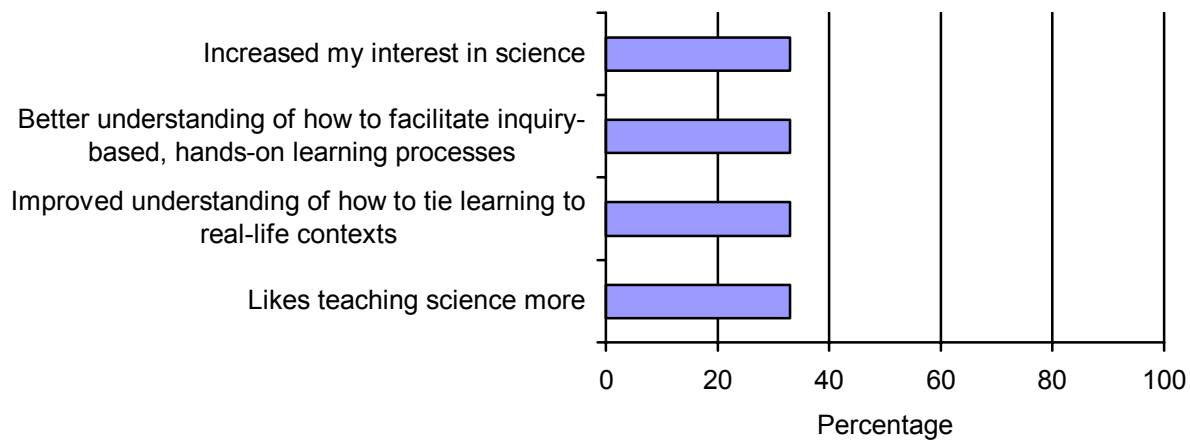
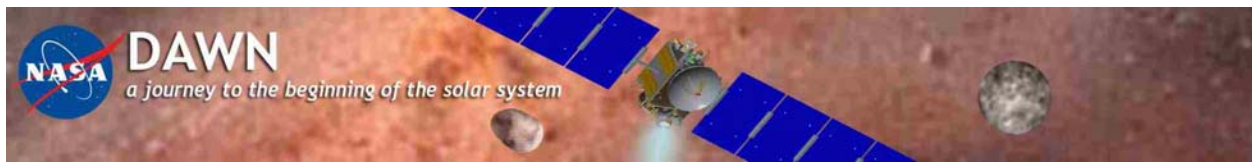


Figure 11. The percentage of teachers (n=3) who agreed with statements regarding their use of the module.

Only one of the pilot teachers indicated that he/she felt comfortable using the module, that it enhanced his/her capacity to teach science, and that it resulted in changes in his/her instructional practices. Again, it is important to note that this reflects feedback from only 2-3 pilot-test teachers,

¹⁰ This information was not provided for one of the schools with 35 participating students. It is expected that there will be a larger number of economically or academically disadvantaged students in the field testing of this module.



who introduced the content module to the classroom for the first time. The feedback from pilot-test teachers greatly informed the revision process of the content module.

Professional Development

Calibrated Peer Review (CPR) is a web-delivered software package that is designed to implement writing as a learning activity. Most often in school, educators use writing as an artifact for learning. CPR uses writing as a part of the learning process. Students are given a writing assignment with guiding questions to help in formulating the essay. Once the essay has been written, instructors calibrate students' abilities to review written work. As part of this process, instructors give students three essays of differing quality and assess their abilities to review the three essays appropriately. Based on students' reviewing abilities, the instructor then gives students three essays from their peers to review. The last phase occurs when students receive their own essay with three peer evaluations. Teachers have access to student work and progress at all times through a web-accessible interface.

The Dawn E/PO team collaborated with Arlene Russell from UCLA to deliver its first professional development workshop on Calibrated Peer Review with five teachers during this past year. The three-day workshop introduced CPR to teachers and allowed them to experience, first hand, the learning process as integrated with the Dawn education materials. Participants were asked to complete a feedback form that included questions about the quality and utility of the workshop as well as suggestions for improvement. Figure 12 presents participants' mean ratings for items regarding the quality and utility of the workshop (5= "to a great extent," 1= "to no extent").

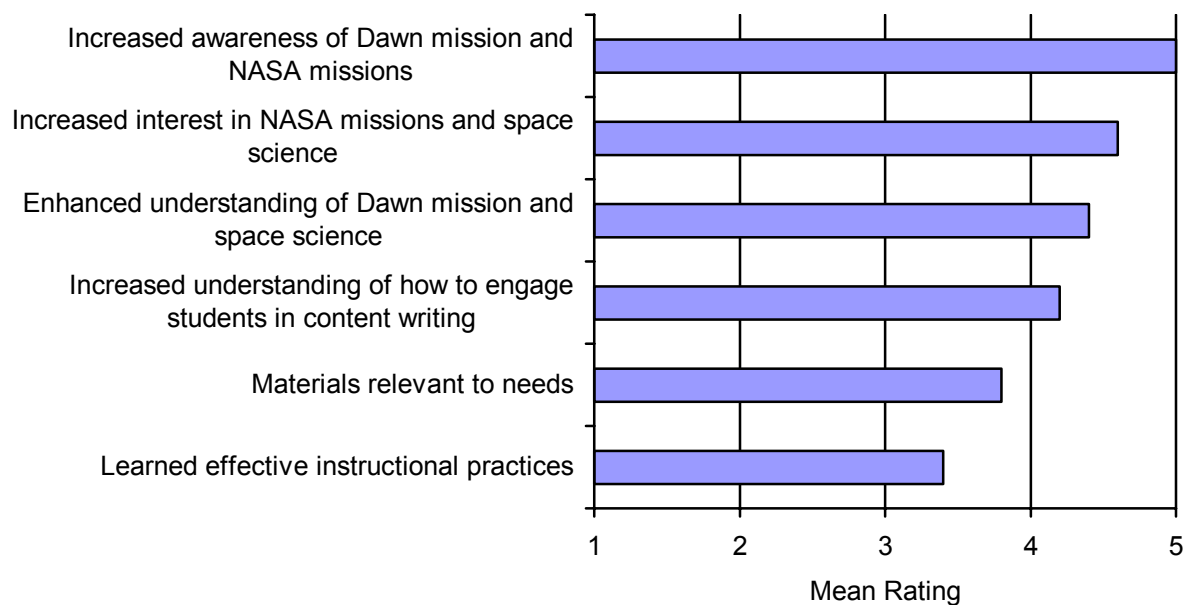
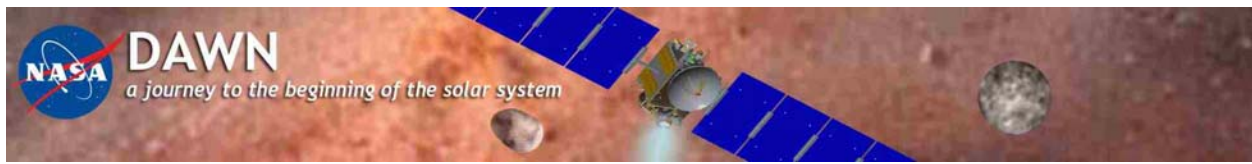


Figure 12. Participants' mean ratings related to the quality and utility of the CPR workshop.

All participants indicated that—at least to some extent—the presentation (1) increased their *awareness*



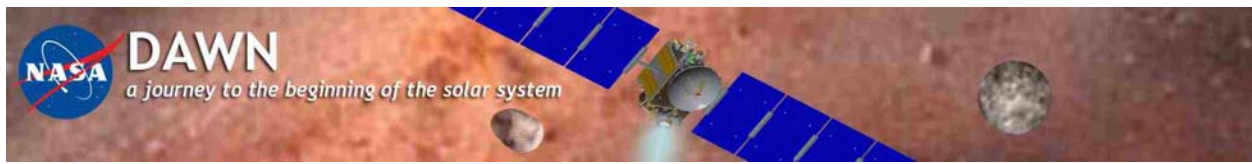
of the Dawn mission and NASA mission in general ($\chi = 5.00$), (2) increased their *interest* in NASA missions and space science ($\chi = 4.60$), and enhanced their *understanding* of the Dawn mission and space science ($\chi = 4.40$). At least to some extent, teachers thought the materials were relevant to their needs ($\chi = 3.80$), and that they had learned effective instructional practices to use in their work ($\chi = 3.40$) and how to engage students in content writing assignments ($\chi = 4.20$). Overall, participants gave this workshop a quality rating of “good” ($\chi = 4.00$; on a 5-point scale). Many of the teachers are sharing what they learned from the CPR with other teachers in their schools. When asked about suggestions for improvement, most participants provided feedback on the quality, usability, and appropriateness of the software program for their teaching environments.

SUMMARY

During this past project year, E/PO efforts focused on building the Web site and its content, developing educational materials, promoting educator awareness of and interest in the Dawn education materials, and reaching audiences through conferences and public events. In its first five months, the Dawn mission Web site experienced 923 visits and 15,223 page views from people accessing the site. Sixty-eight percent of the page views resulted from visitors accessing the Web site from external pages and 27 percent were from visitors entering the Web address directly or using a bookmark. Almost all visitor sessions originated from the United States, although the site had a very small amount of international visitors.

In their first seven months of outreach, members of the team represented the Dawn mission at 12 education or public events, conferences, workshops, etc., including one international presentation. Overall, the Dawn E/PO team reached almost 100 teachers across six states through presentations and professional development workshops. Additionally, over 100 students had the opportunity to engage in the science materials through their participation in a pilot-test of the first content module, the *History and Science of NASA's Dawn Mission*.

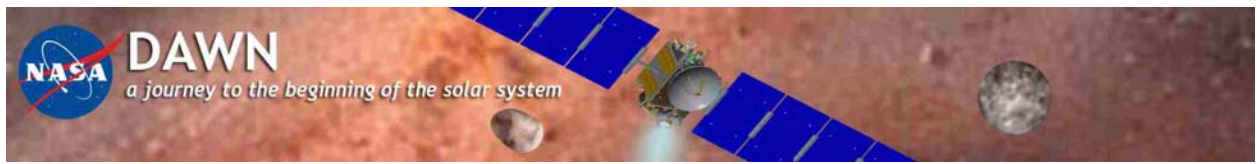
The results from the pilot-test of the *History and Science of NASA's Dawn Mission* content module reveal that students experience significant learning gains in their knowledge about the historical periods involving the discovery of asteroids and the associated technological, political, and social contexts influencing the discovery process. Overall, teachers found the materials to be of high quality and utility. Both teachers and students provided valuable formative feedback on the implementation and use of the content module. This feedback guided intensive revisions to the module and included adjusting the reading level of the vignettes and developing a teacher's guide supplement. The supplement contains a list of main ideas for the vignettes, the standards to which the materials are aligned, and student questions and answers. It is expected that revisions will result in a more useful, appropriate, and adoptable product for educators and learners. The revised content module will be field-tested during the upcoming project year.



RECOMMENDATIONS

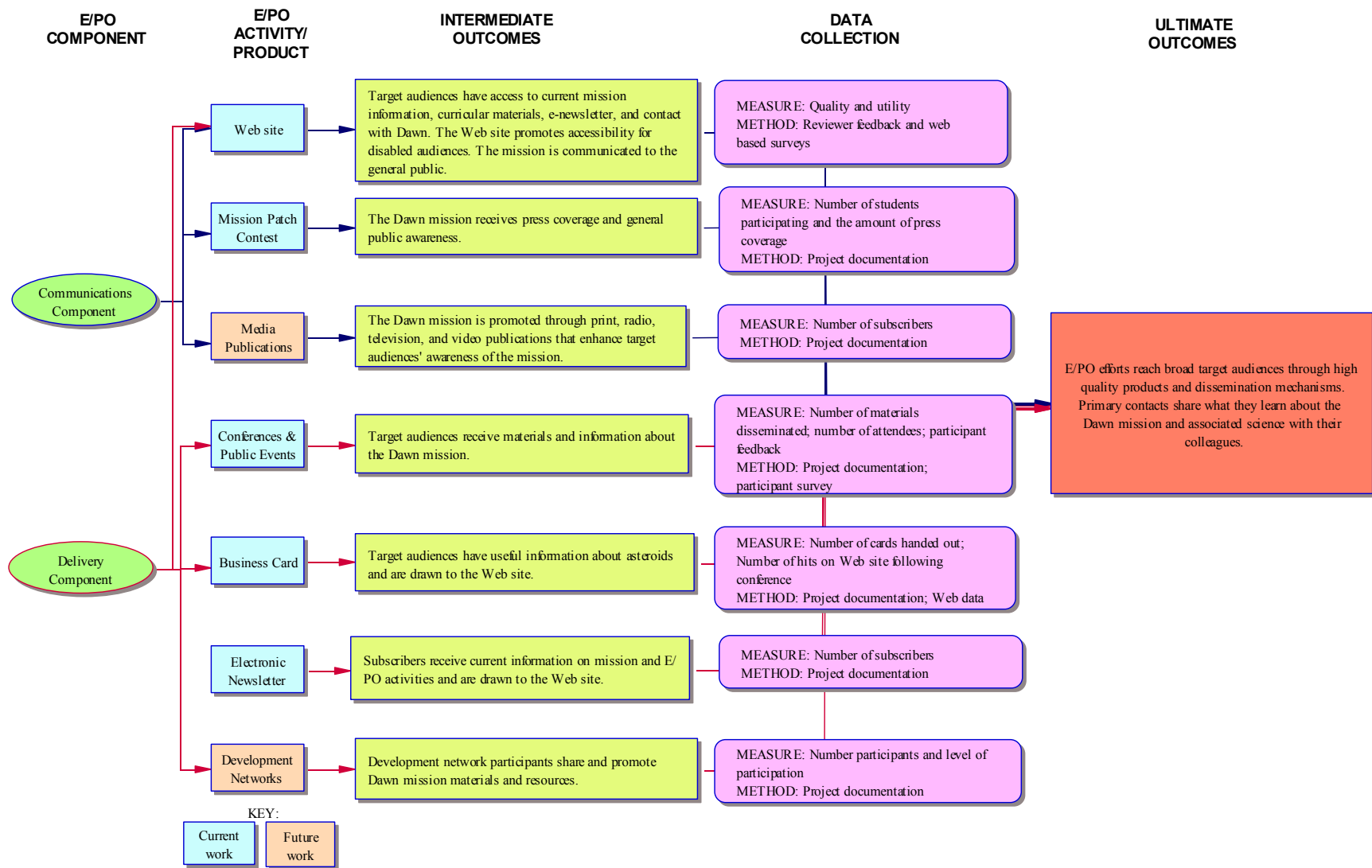
Based on the evaluation findings to date, the following recommendations are provided for consideration by the Dawn E/PO team. These suggestions are intended to facilitate continued project success in project implementation and assure accountability with regard to project outcomes (see Appendix B for team members' response to these recommendations).

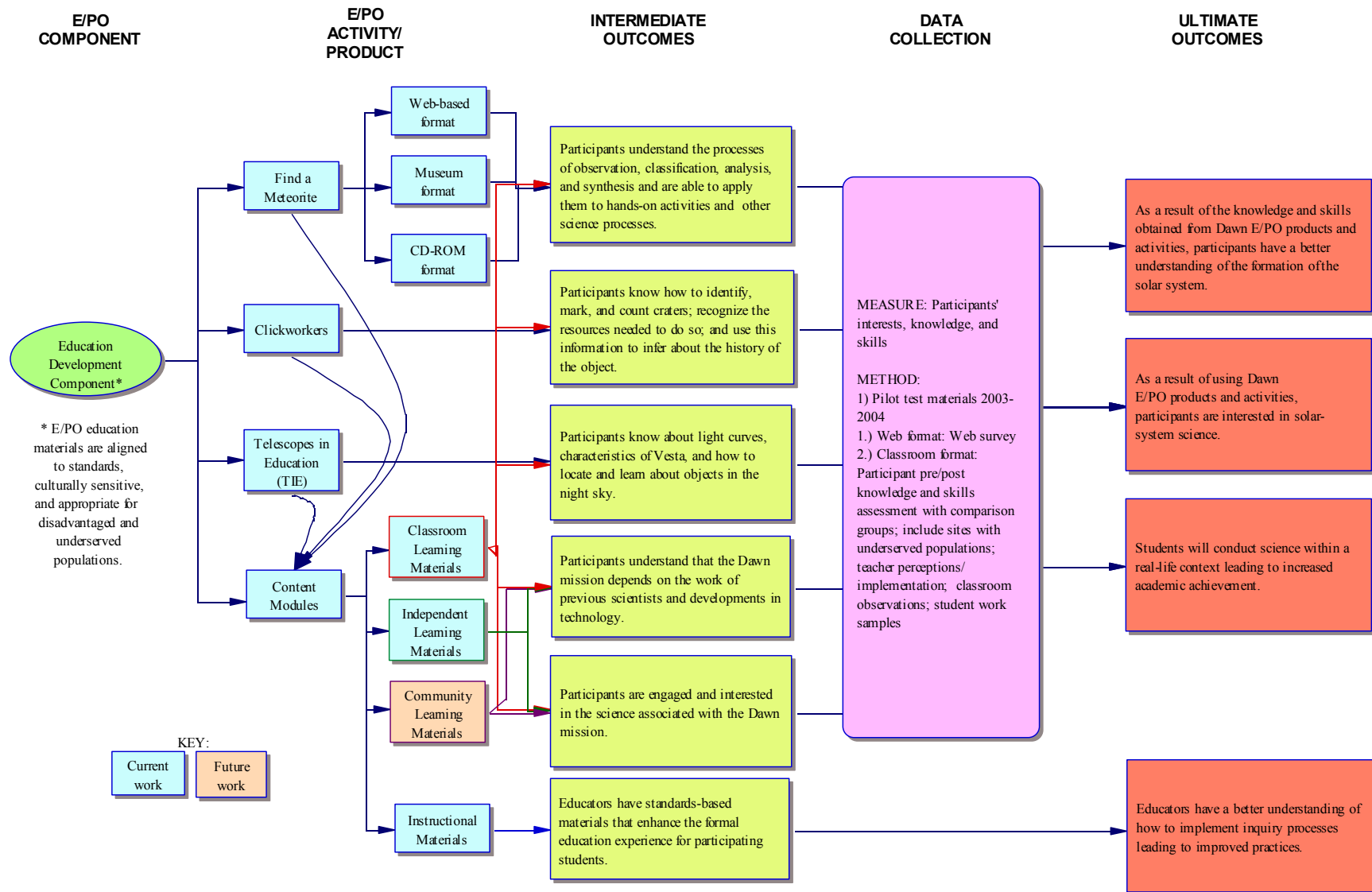
- As outreach development expands during the upcoming year, it is expected that efforts will target public and informal educator audiences more specifically. It is recommended that team members continue to forge partnerships with museums, science centers, media representatives, and space-related networks, such as NASA's Space Grant Consortia, JPL's Solar System Ambassadors and Solar System Educators Program, Explorer Schools, and after-school programs in order to solidify effective dissemination infrastructures prior to launch.
- Given that members of the Dawn science and engineering teams conduct significant outreach, it is recommended that E/PO team members create ways to educate science and engineering team members of the availability of Dawn outreach materials and resources.
- Given that meaningful, formative feedback was provided by pilot-test teachers and students, it appears that the development and quality assurance process implemented by the team is beneficial to improving the quality and utility of the materials. It is recommended that team members continue to submit all educational materials through this process before making them available to broader audiences.
- Given the importance of the pilot and field testing, it is recommended that team members continue to think strategically about all recruitment efforts to ensure that materials are studied in various educational settings including underserved and underrepresented sites, museums, and after-school programs.
- Given that the Calibrated Peer Review represents an important instructional tool to the E/PO team, it is recommended that team members revise the workshop and the instructional tool to incorporate participant feedback. Furthermore, it is suggested that team members organize cost-effective and various training opportunities to involve a greater number of educators in future CPR workshops.

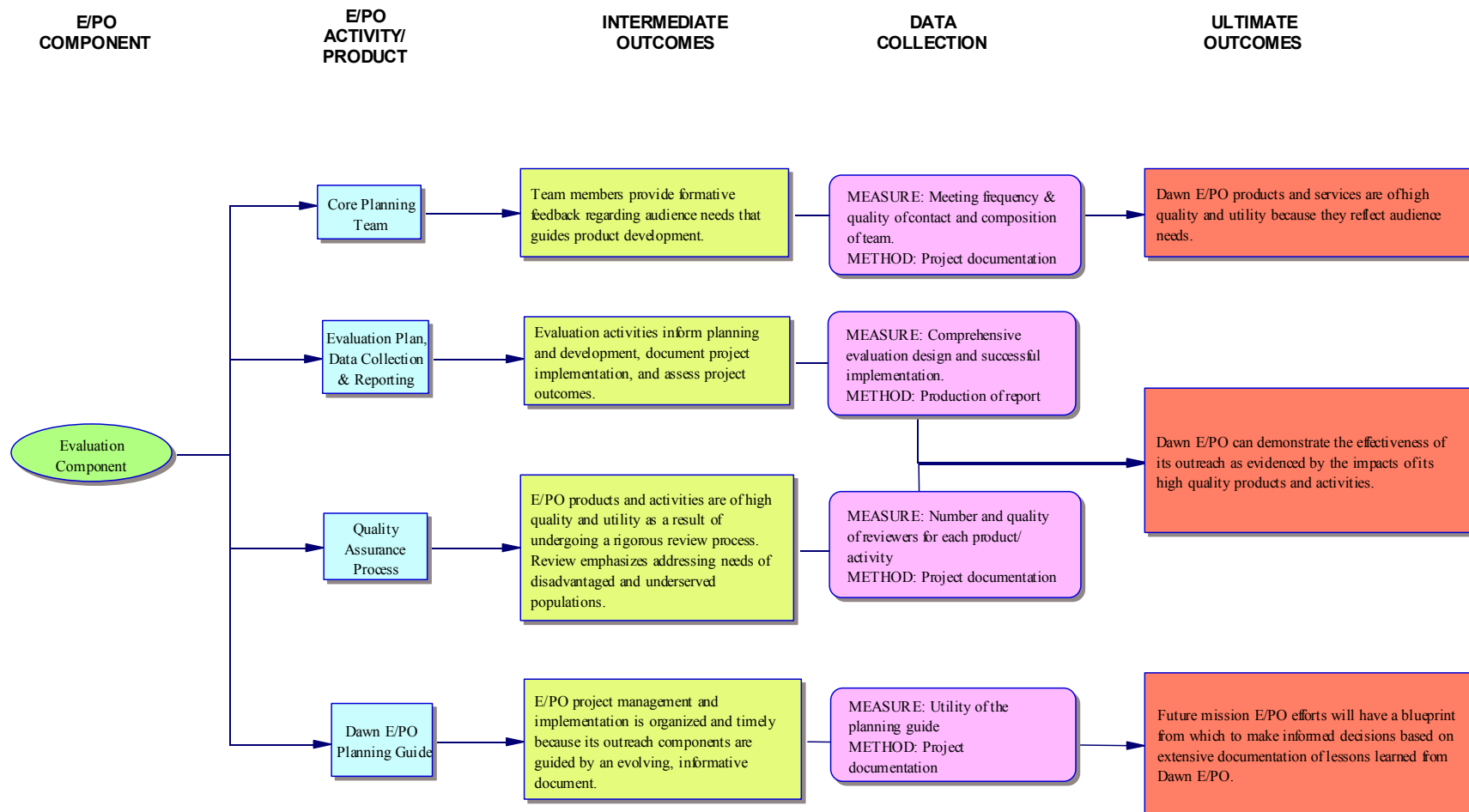


APPENDIX A:

Logic Models for Dawn Education and Public Outreach







APPENDIX B:

E/PO Team Members' Response to Report Recommendations

Response to Dawn E/PO Year One Evaluation

Recommendation #1: Forge partnerships with museums, science centers, media representatives, and space related networks.

Response: As Dawn E/PO approaches launch, we will expand our relationships with informal science centers in a number of important ways. These include utilizing informal networks, involving informal staff members in product development through the Core Planning Team (CPT), involving informal opportunities for field testing educational materials especially made for informal settings, and partnerships for museum exhibits and planetarium shows.

Dawn E/PO west-coast efforts will involve assisting media outlets such as the Discovery Channel in the production of television programming. Mr. Joe Wise will work directly with boys/girls clubs and astronomy clubs as CPT and field testing venues. Mr. Wise has recently attended and provided information at the National NASA Space Grant Consortia meeting. We also plan on attending the Western Alliance Conference of the International Planetarium Society. On the east-coast, Dr. Lucy McFadden has established a relationship with the Maryland Science Center for possibly field testing the Find A Meteorite (FAM I) materials. McREL has developed a relationship with the Kentucky Challenger Center and Girls Inc. for FAM I pilot and field testing. Additionally, McREL has worked with the Brevard Planetarium in Florida for a potential launch educator conference. In the Central Region, McREL plans to involve the Denver Museum, Houston Museum, and 4-H clubs in Kansas in informal education materials. For example, the Houston Museum is planning a meteorite exhibit next summer that represents a good venue for a Dawn presence. Nationally, Dawn E/PO will network with Space Grant Consortia, targeted emails to museums in Dallas, Chicago, and New York as well as the Association of Science and Technology Centers (ASTC). In the Dawn E/PO Guide we have outlined our plans to work with JPL Solar System Ambassadors and Educators (page 14). The guide details public engagement (page 9) and a national mission patch contest (page 13).

Recommendation #2: Educate scientists and engineering teams about Dawn outreach materials and resources.

Response: As we move closer to launch, Dawn E/PO could use a “pull-out” activity from the Informal Leader Guide for Dawn science and engineering teams to use when they conduct school visits. We could investigate using Web X time (synchronous meeting) and/or E-Campus (Asynchronous) for science and engineering teams to ask questions and receive answers about educational materials. We will also provide opportunities for science and engineering teams to provide interview content, and input into development and review of educational materials.

Recommendation #3: Continue to submit all educational materials through the process.

Response: We will continue to use the development process outlined in figure 1 on page 6 of the Dawn E/PO guide. This process has worked particularly well for us as evidenced by the following adjustments we have made to materials in response to formative assessment results.

Summary of Dawn Content Module Revisions

During the spring of 2004, Dawn E/PO conducted a pilot test of content module 1, *The History and Science of NASA's Dawn Mission*, in two middle schools. Through a series of site visits, surveys, interviews, and student assessment results, Dawn E/PO gathered data on the instructional effectiveness of the module materials. Using these data, the Dawn E/PO development team made extensive revisions to the module in preparation for the Fall 2004 field test. Revisions included: a) narrowing the scope of the module; b) replacing content deemed to be too challenging for the target audience with appropriate instructional activities and strategies; c) modifying existing student texts to more closely match the readability with the intended grade level; and d) realigning the pre- and post-knowledge and skills assessment.

Scope of the Module

Pilot-test feedback revealed that the module was too robust to implement in a 3-week timeframe. As a result, students who were initially engaged in the space exploration materials began to lose interest. Furthermore, the module delivered detailed historical content spanning from Ptolemaic times to the future Dawn mission. The revised module still provides historical snapshots of significant moments in asteroid discovery; however, the emphasis is on understanding larger concepts such as the process of scientific inquiry and the relationship between science and technology.

Replaced Content

To narrow the scope of the module, the E/PO writing team removed content that was considered too challenging or confusing for the target audience. Several student texts (or vignettes), focusing on sophisticated technology and instrumentation, were removed from the middle school module with the intent of repurposing them for a later high school-level module. Subsequently, the corresponding activity, *Vegetable Light Curves*, no longer fit with the content presented and was also taken out of the module. The revised module includes two new activities—graphing and creating physical models—both of which will help students better understand important concepts related to asteroid discovery and Dawn. In addition, a new student text, written in the style of a timely news story, was added to help students better understand the objectives of the Dawn mission and its logical place in the progression of space exploration throughout history.

Pilot-test participants also struggled with the ongoing timeline activity as well as the culminating interaction/synthesis project. Feedback revealed that students needed more guidance and

clarification in identifying important information to include in each of the timeline tiers (science, scientific process, history, and technology) and synthesizing the information to develop an understanding of the interplay among these factors. Based on this feedback, the field-test module employs guided reading and small-group discussion strategies instead of the ongoing timeline activity. This approach allows students to focus on one perspective (formerly called timeline tier) at a time: history, science, and technology. Ongoing collaborative opportunities infuse the process of synthesizing information throughout the module—a skill that requires practice—as opposed to waiting until the end of the module for the interaction/synthesis project. These ongoing activities seamlessly lead up to a culminating timeline project. Rather than offering several choices of projects, each of which emphasized a different learning style, the collaborative timeline project incorporates a variety of learning strengths (e.g., visuals, writing, and oral presentations). The E/PO writing team perceives the newly revised module to be more focused and suitable for the intended grade levels.

Modified Student Texts

Pilot-test evaluation revealed that the student texts or vignettes included in the module were significantly above the middle-school reading level. In addition to removing some of the more challenging technical texts, as mentioned above, the remaining texts were revised to more closely match the readability to a middle school reading level. Using a grade level readability check, the readability of most vignettes dropped several grade levels. Furthermore, to promote reading comprehension, a glossary was provided for the first time to field-test participants.

Revised Pre- and Post-Tests

During pilot testing the “use of the materials resulted in an increase in (student) understanding of the science concepts and standards embedded in the materials” (Dawn Mission Education and Public Outreach First-year Evaluation Report, page 15). After a careful analysis of pilot-test students’ performance on the knowledge and skills assessment, the E/PO development team identified problematic test questions and either revised or eliminated them to better evaluate the impact of the Dawn materials on student achievement during the field test. The development team also added some additional test items that were designed to more closely align with the new module content.

Recommendation #4: Think strategically about recruitment efforts to ensure that materials are studied in various educational settings including underserved and underrepresented sites, museums, and after-school programs.

Response: We should broaden our field testing announcements to NSTA National and State level newsletters. We should also send targeted email announcement to organizations such as CAPS and SACNAS for field testing materials to underserved populations. See response to #1 for how we plan to involve informal educators.

Recommendation #5: Revise CPR workshop to incorporate participant feedback.

Response: We will offer a one hour CPR awareness session at the Colorado Science Teachers and Kansas Association of Teachers of Science conferences. We will incorporate feedback from summer 2004 as we plan and conduct a CPR session this summer in association with a school district.